Evaluation of NCAR's AutoNowCaster for Operational Application within the National Weather Service

**VLab Forum
June 15, 2016**

Presenter: John Crockett, CIRA/CSU

The AutoNowCaster (ANC) Team

NOAA / NWS / MDL

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Mamoudou (Ama) Ba, Project Manager

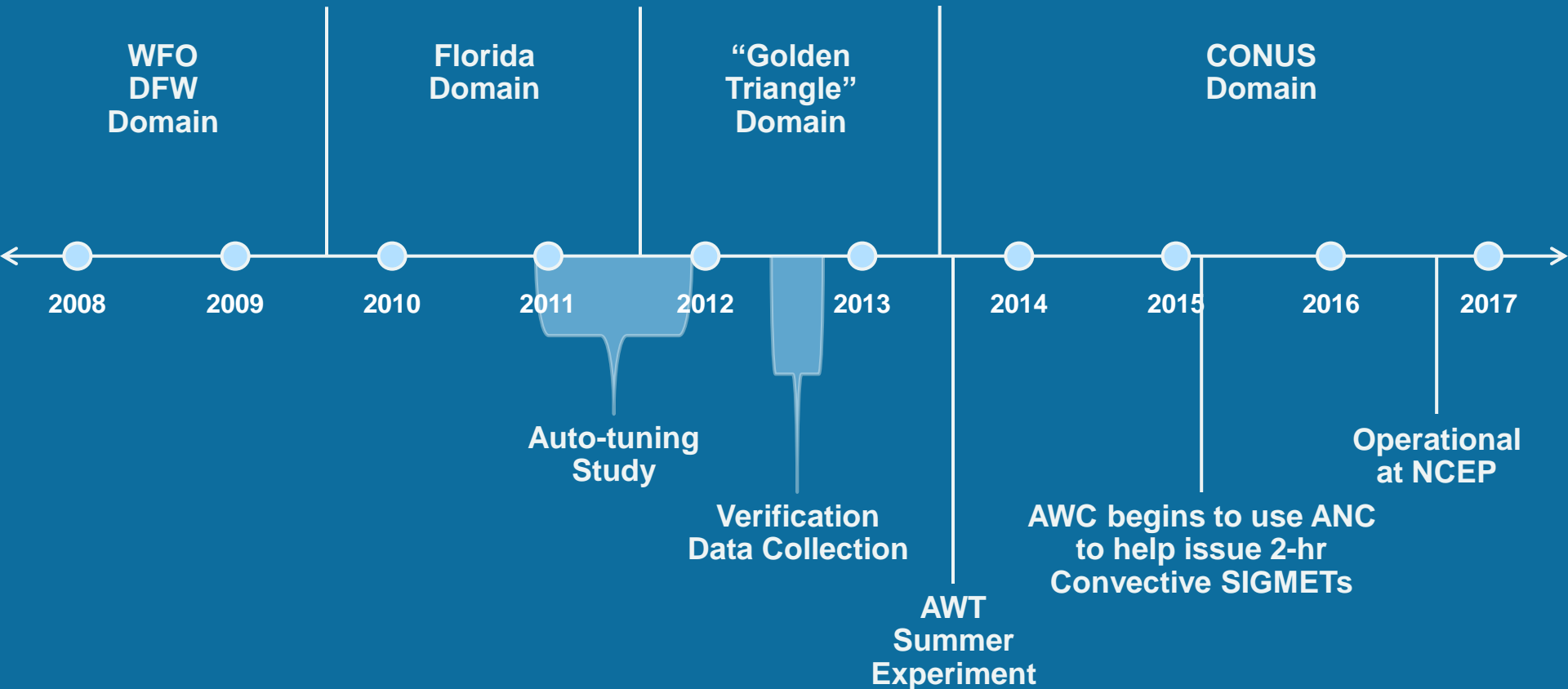**Lingyan Xin, Verification Analyst**

CIRA / CSU

John Crockett, Technical Lead

Kenneth Sperow

NCAR / RAL

Rita Roberts, Principal Investigator

Daniel Megenhardt

ANC: MDL Timeline

WFO DFW Domain

Florida Domain

"Golden Triangle" Domain

CONUS Domain

2008   2009   2010   2011   2012   2013   2014   2015   2016   2017

Auto-tuning Study

Verification Data Collection

AWT Summer Experiment

**AWC begins to use ANC to help issue 2-hr Convective SIGMETs**

Operational at NCEP

ANC: Overview

- ANC is designed to nowcast areas where storms are considered likely to form and/or be sustained, and vice-versa. How?

- ANC ingests NWP model output, GOES satellite data, surface METAR data, and NWS radiosonde data in order to analyze characteristic features of the atmosphere.   The results of the analyses are 60-minute predictors which are converted into dimensionless likelihood fields.

- The likelihood fields have a dynamic range from -1 to 1, where increasing positive values correspond to an increasing likelihood of storm initiation and/or sustainment, and vice-versa.

- The likelihood fields are weighted and summed to produce a 60-minute Convective Likelihood (CL) field.

- In essence, ANC attempts to analyze, weight, and sum various data in a manner analogous to that of a forecaster.
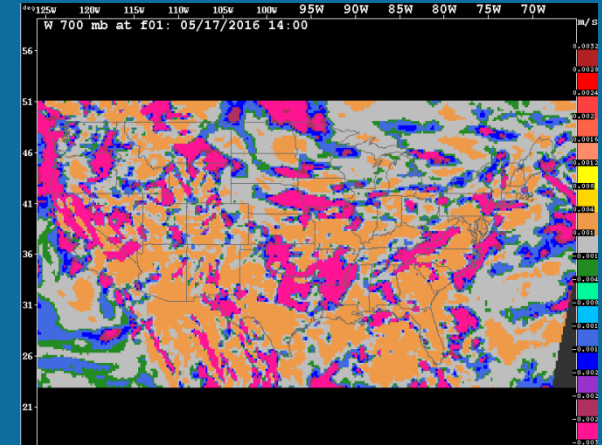
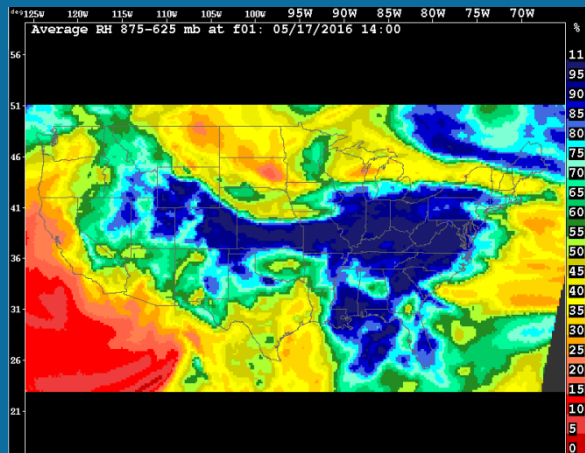# ANC Predictors: Dynamics
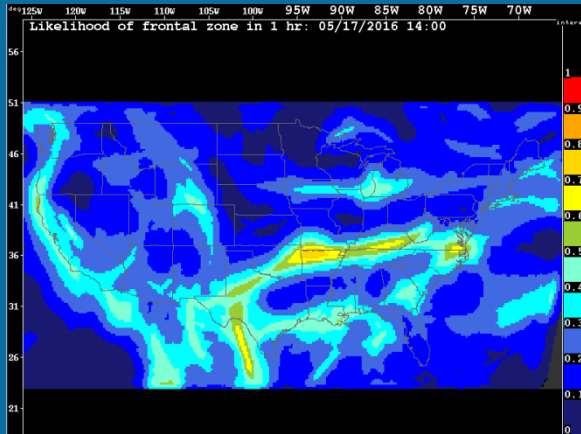
Likelihood of Frontal Zone in 1 hr
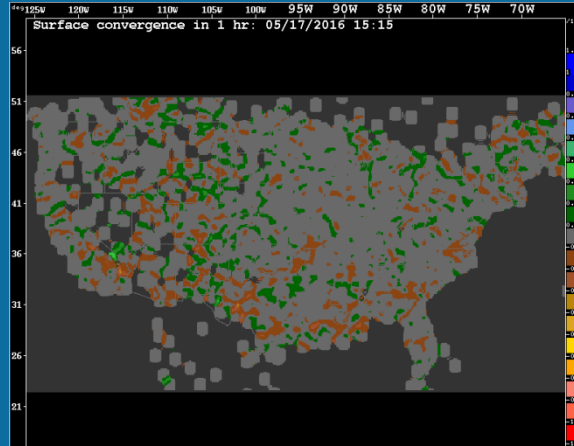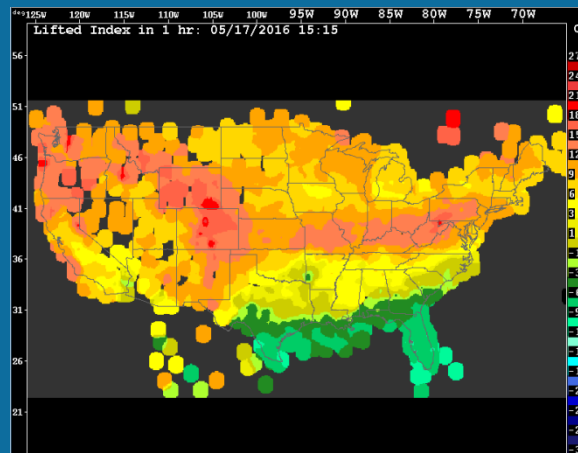

Surface Convergence in 1 hr
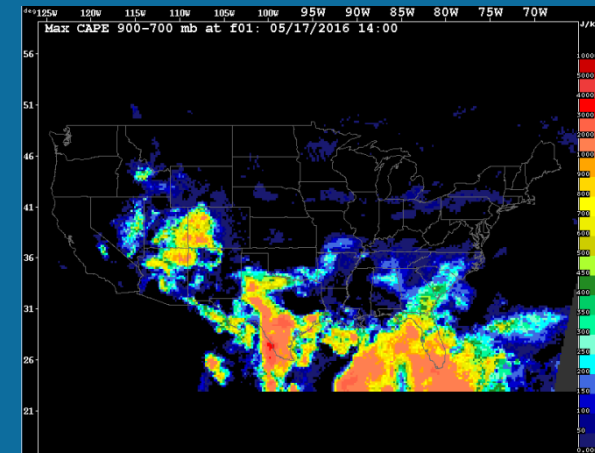

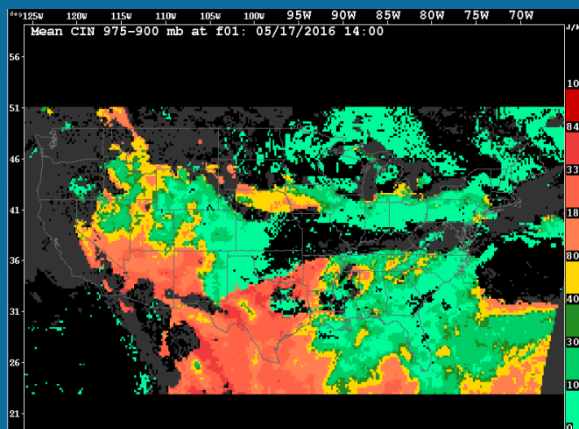**W 700 mb at f01**

ANC Predictors: Thermodynamics
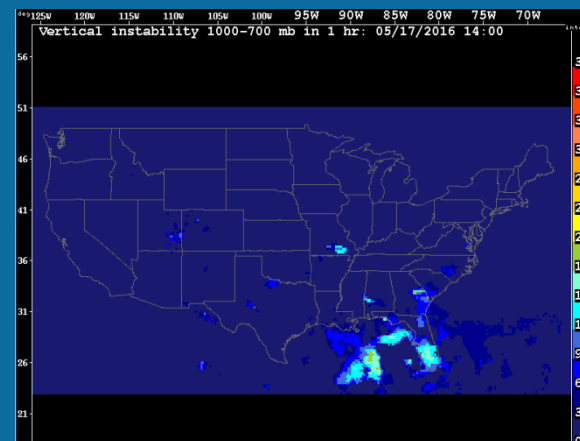

Average RH 875-625 mb at f01

Lifted Index in 1 hr

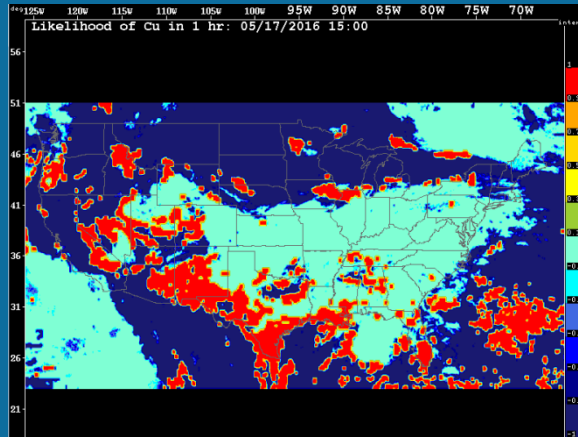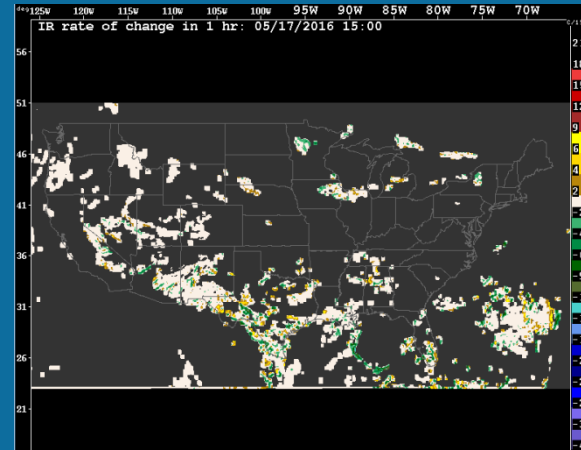Max CAPE 900-700 mb at f01

Mean CIN 975-900 mb at f01

Vertical Instability 1000-700 mb in 1 hr

ANC Predictors: Clouds
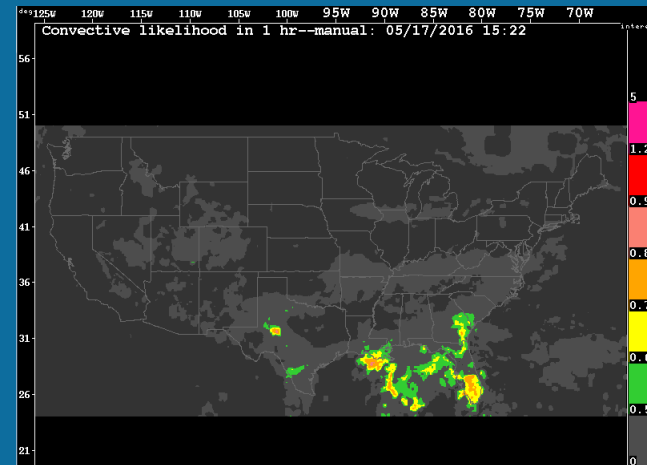

Likelihood of Cu in 1 hr

IR Rate of Change in 1 hr

ANC Predictand:
Convective Likelihood (CL) in 1 hr

$(0.22 * F_1$ (Likelihood of Frontal Zone in 1 hr)) +

$(0.08 * F_2$ (W 700 mb at f01)) +

$(0.10 * F_3$ (Surface Convergence in 1 hr)) +

$(0.18 * F_4$ (Average RH 875-625 mb at f01)) +

$(0.20 * F_5$ (Lifted Index in 1 hr)) +

$(0.20 * F_6$ (Max CAPE 900-700 mb at f01)) +

$(0.12 * F_7$ (Mean CIN 975-900 mb at f01)) +

$(0.12 * F_8$ (Vertical Instability 1000-700 mb in 1 hr)) +

$(0.12 * F_9$ (Likelihood of Cu in 1 hr)) +

$(0.40 * F_{10}$ (Likelihood of Clear Sky in 1 hr)) +

$(0.10 * F_{11}$ (IR Rate of Change in 1 hr))

$F_\#$ denotes a predictor-specific fuzzy function.

$=$
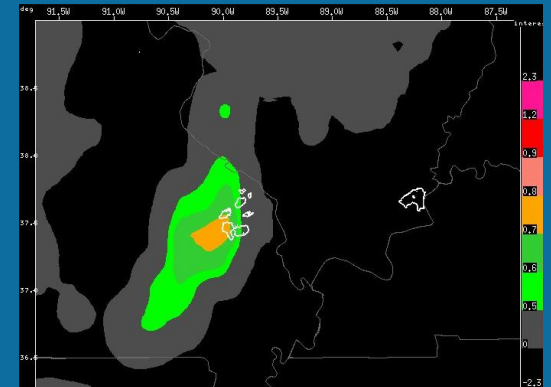

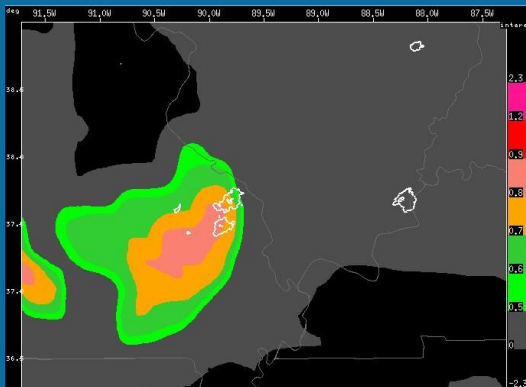**Convective Likelihood in 1 hr**

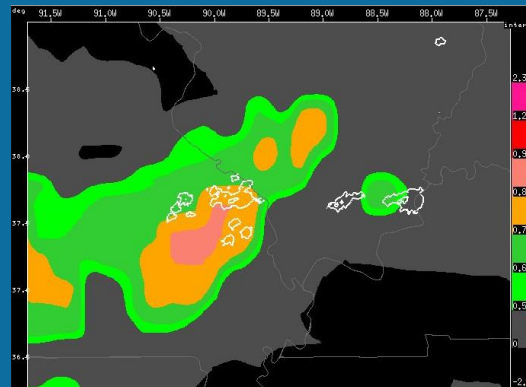# ANC: Example Time Series
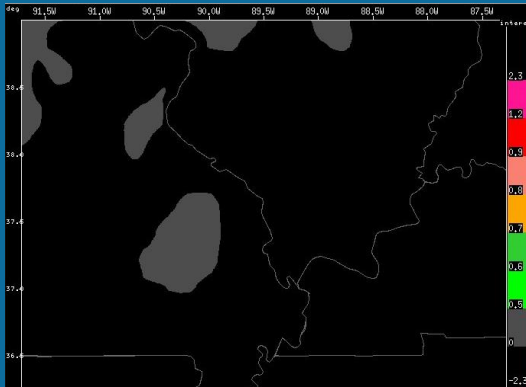
Valid time: 1741Z
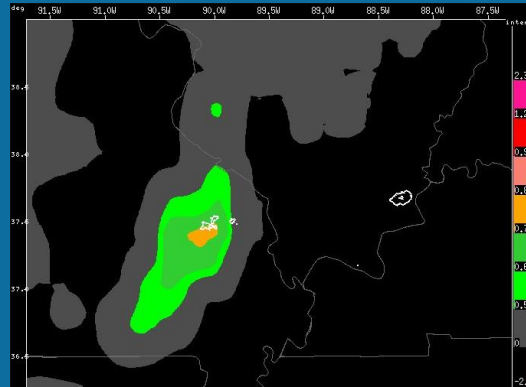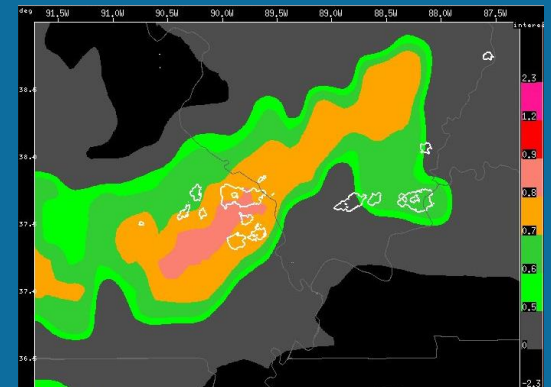
Valid time: 1838Z

Valid time: 1853Z

Valid time: 1908Z

Valid time: 1929Z

Valid time: 1944Z

60-min nowcasts of CL on July 1, 2012 overlaid with 35 dBZ contours at the valid time

ANC Verification: Questions

- What is the smallest spatial scale at which ANC's 60-minute nowcasts of CL can skillfully nowcast the general areas where *both* new storms may initiate *and* existing storms should be sustained, and to what values of CL does this apply?

- What is the smallest spatial scale at which ANC's 60-minute nowcasts of CL can skillfully nowcast the general areas *solely* where new storms may initiate, and to what values of CL does this apply?

- To what degree, if any, are ANC's 60-minute nowcasts of CL subject to temporal ambiguity?

ANC Verification: Domain
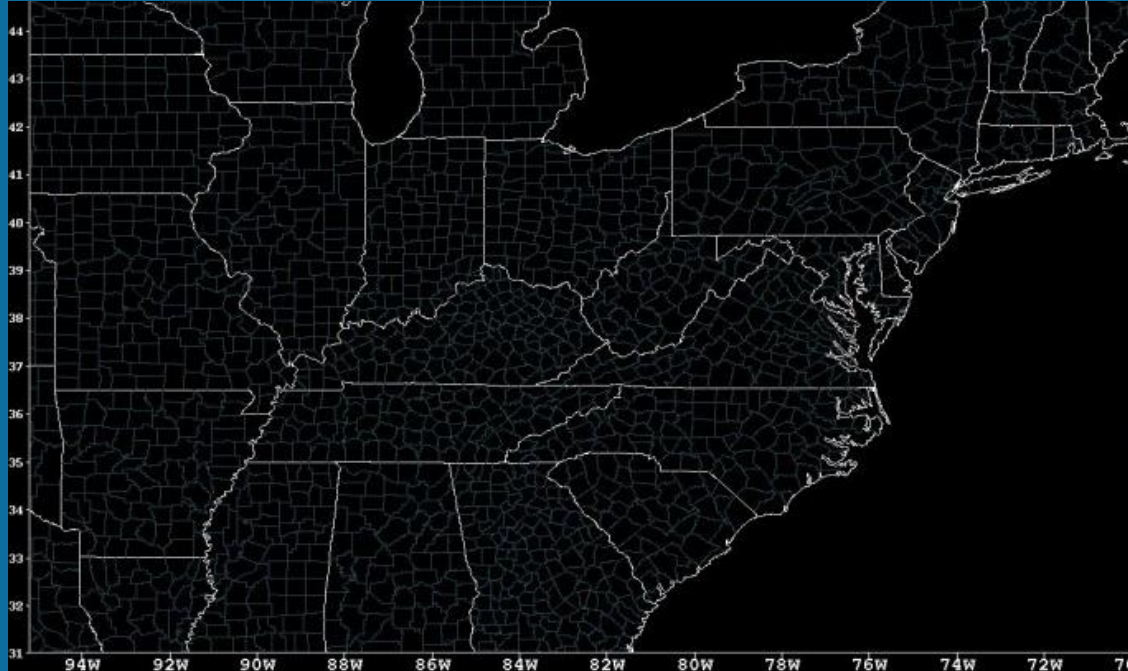
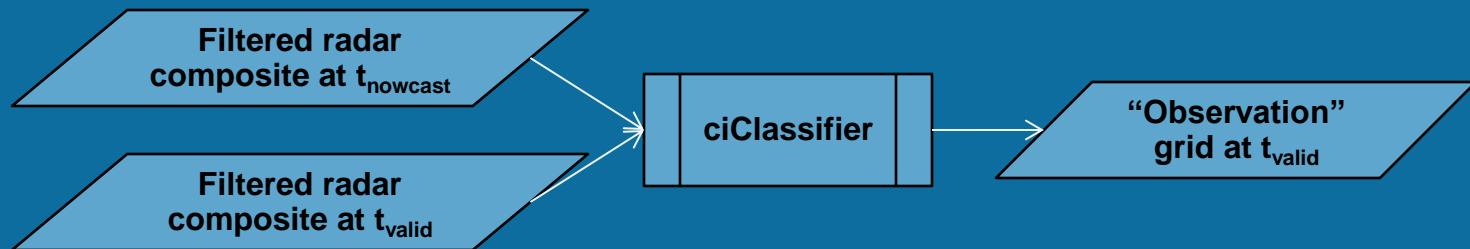The "Golden Triangle" Domain: 31° to 45° N; 94° to 71° W; 0.02° x 0.02°

ANC Verification: Data

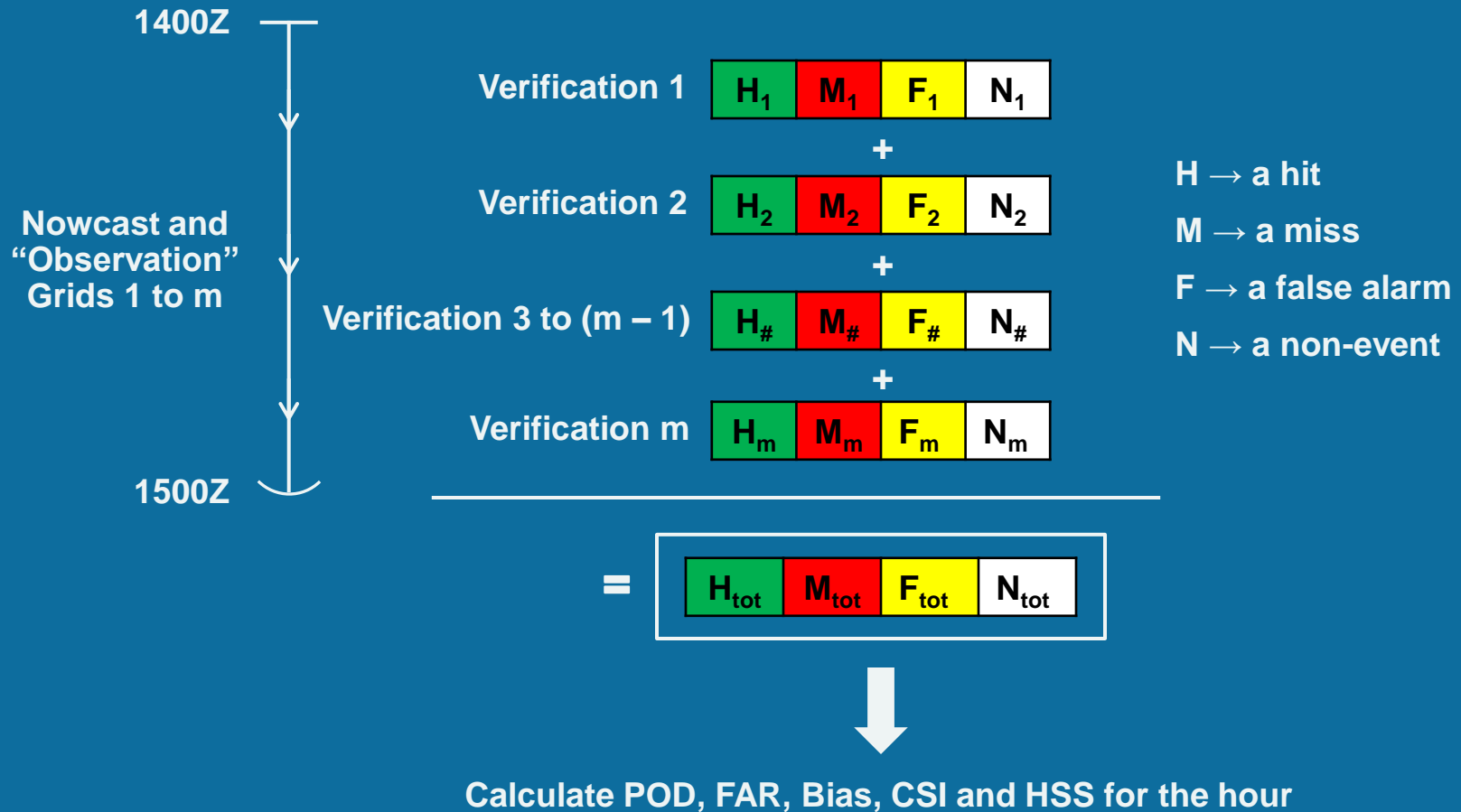1. **Nowcast grids of ANC's predictand: CL in 1 hr**

   - **55 days from June 11 to September 30, 2012; 1400Z to 2359Z; ~10 nowcasts per hour**

2. **"Observation" grids derived from 3-D Cartesian WSR-88D reflectivity volumes**

   - **Reflectivity volume**
       - **Filtered for bright band data**
           - **Filtered for stratiform data**
               - **Composited between 2.5 and 4.5 km, inclusive**

ANC Verification: Statistics

1400Z

Nowcast and
"Observation"
Grids 1 to m

1500Z

Verification 1 H_1 M_1 F_1 N_1

+

Verification 2 H_2 M_2 F_2 N_2

+

Verification 3 to (m – 1) $H_\#$ $M_\#$ $F_\#$ $N_\#$

+

Verification m H_m M_m F_m N_m

$=$ H_{tot} M_{tot} F_{tot} N_{tot}

$H \rightarrow$ a hit

$M \rightarrow$ a miss

$F \rightarrow$ a false alarm

$N \rightarrow$ a non-event

Calculate POD, FAR, Bias, CSI and HSS for the hour

ANC Verification: Spatial Neighborhoods
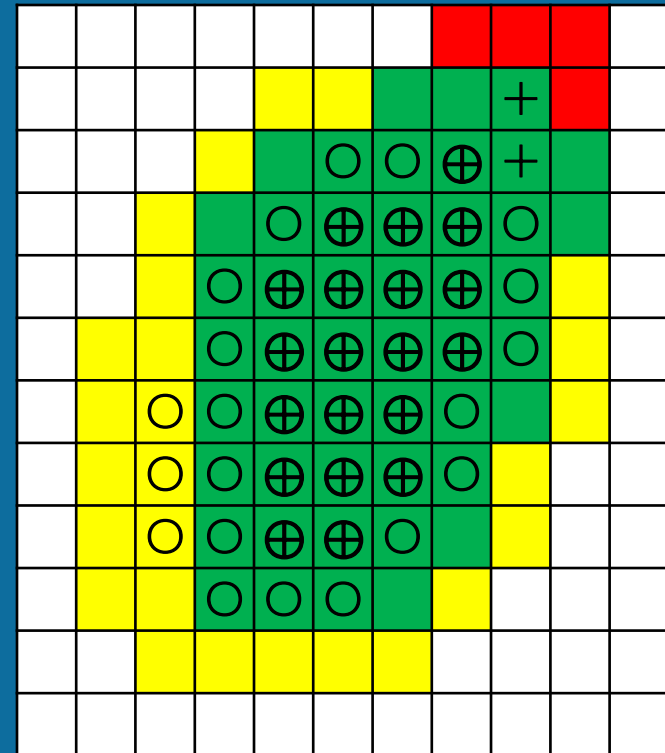
N = the neighborhood size parameter

It yields a (2N + 1) by (2N + 1) neighborhood.

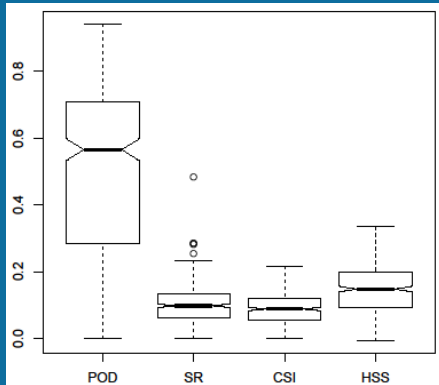O ⟶ an event was forecasted

+ ⟶ an event was observed

⊕ ⟶ an event was both forecasted and observed

■ → a hit
■ → a miss
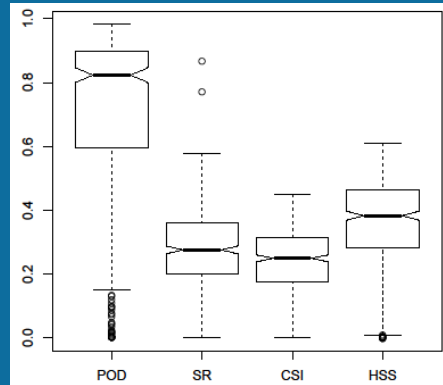■ → a false alarm
□ → a non-event

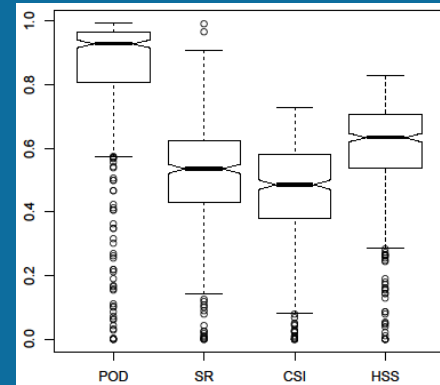**Example verification when N = 1, i.e., a 3 by 3 neighborhood**
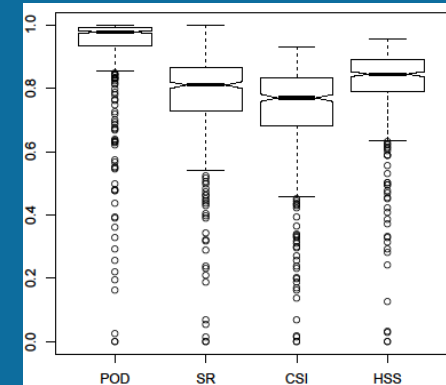
ANC Verification: Results (1)

N = 2 (~10 km^2)
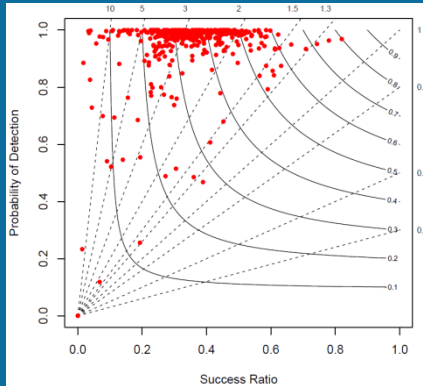Median CSI ~0.1

N = 6 (~25 km^2)
Median CSI ~0.3
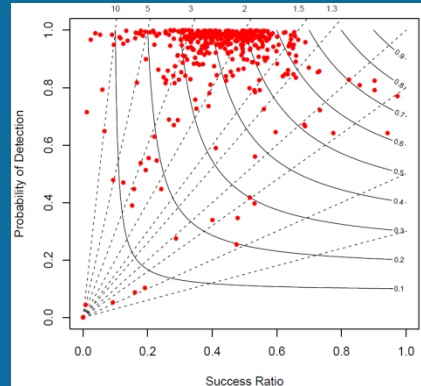
N = 12 (~50 km^2)
Median CSI ~0.5

N = 24 (~100 km^2)
Median CSI ~0.8

Verification for N = 2 (~10 km^2), 6 (~25 km^2), 12 (~50 km^2), and 24 (~100 km^2); a forecast event consists of a nowcast grid point whose CL value ≥ 0.6; an observed event consists of a "truth" grid point classified *either* as new initiation *or* as an ongoing storm
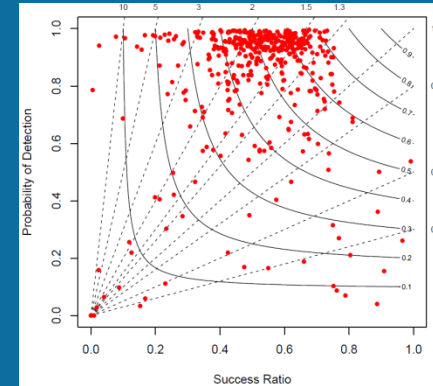
ANC Verification: Results (2)

| CL ≥ 0.4 | CL ≥ 0.5 | CL ≥ 0.6 |

Verification for N = 12 (~50 km^2); a forecast event consists of a nowcast grid point whose CL value ≥ 0.4, 0.5, and 0.6; an observed event consists of a "truth" grid point classified *either* as new initiation *or* as an ongoing storm
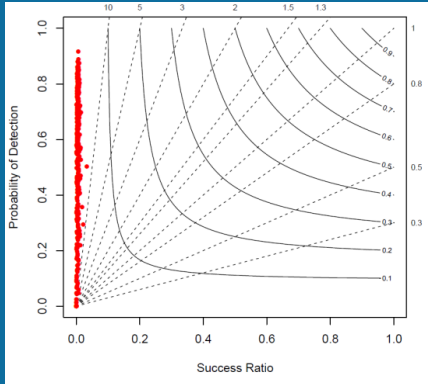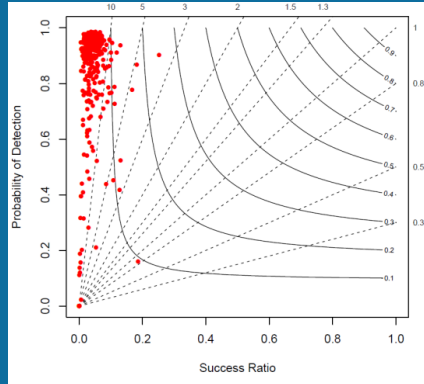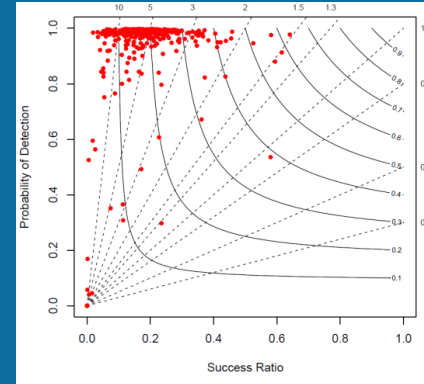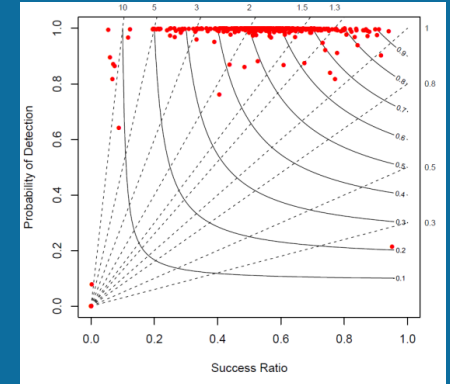
ANC Verification: Results (3)

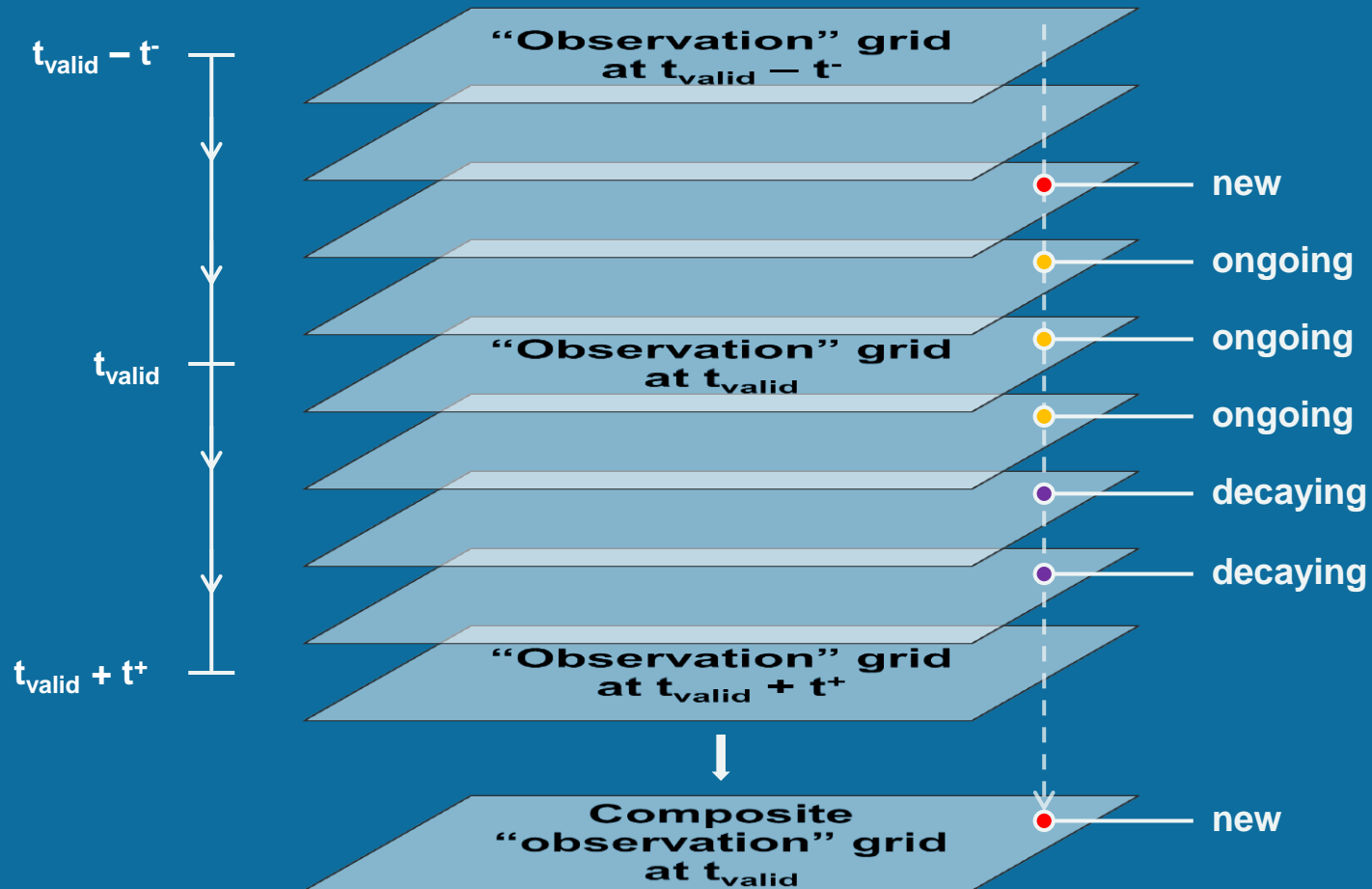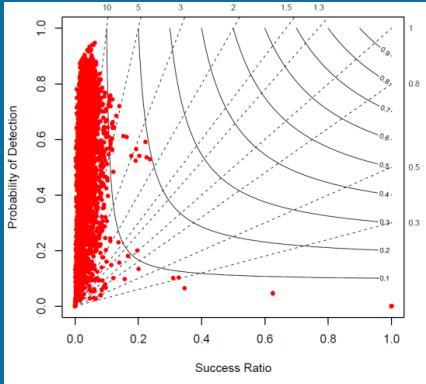N = 2 (~10 km²) N = 6 (~25 km²) N = 12 (~50 km²) N = 24 (~100 km²)

Verification for N = 2 (~10 km²), 6 (~25 km²), 12 (~50 km²), and 24 (~100 km²); a forecast event consists of a nowcast grid point whose CL value ≥ 0.7; an observed event consists of a "truth" grid point classified *solely* as new initiation

ANC Verification: Temporal Relaxation

ANC Verification: Results (4)

N = 2 (~10 km²); t^- **and** t^+ **= 15 min**	**N = 2 (~10 km²);** t^- **and** t^+ **= 30 min**	**N = 6 (~25 km²);** t^- **and** t^+ **= 15 min**	**N = 6 (~25 km²);** t^- **and** t^+ **= 30 min**
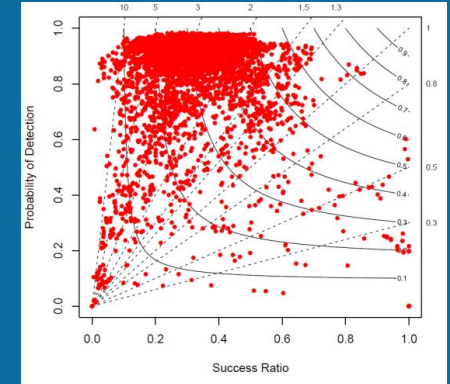
Verification for N = 2 (~10 km²) and 6 (~25 km²); t^- and t^+ = 15 and 30 min; a forecast event consists of a nowcast grid point whose CL value ≥ 0.7; an observed event consists of a "truth" grid point classified *solely* as new initiation
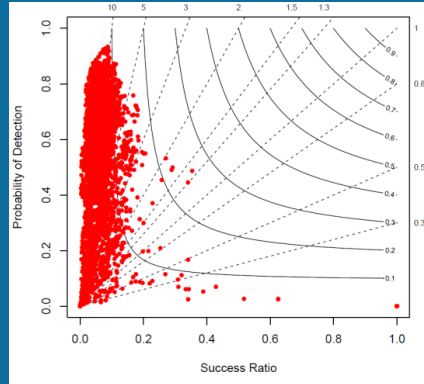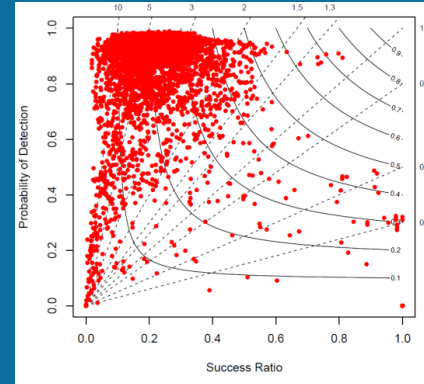
ANC Verification: Results (5)

N = 2 (~10 km²)   N = 6 (~25 km²)   N = 12 (~50 km²)

t⁻ and t⁺ = 15 min

t⁻ and t⁺ = 30 min

Verification for N = 2 (~10 km²), 6 (~25 km²), and 12 (~50 km²); t⁻ and t⁺ = 15 and 30 min; a forecast event consists of a nowcast grid point whose CL value ≥ 0.7; an observed event consists of a "truth" grid point classified *solely* as new initiation
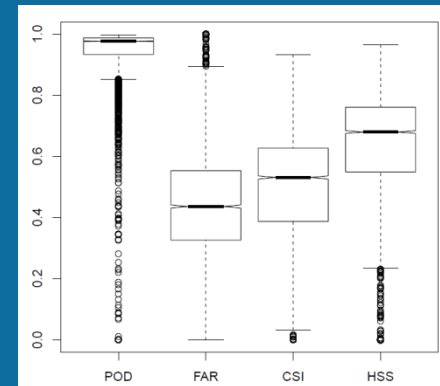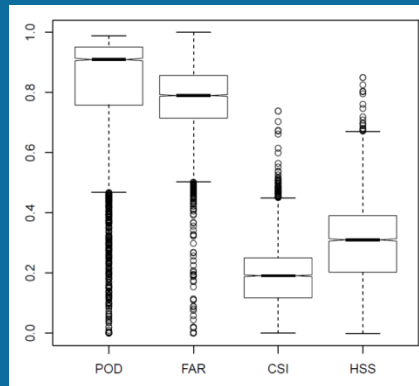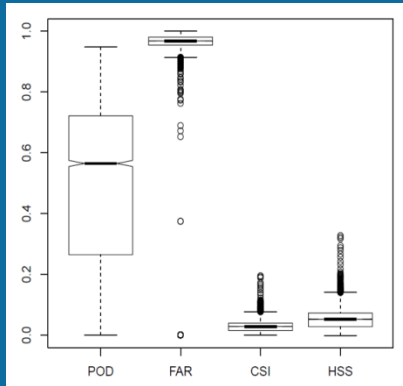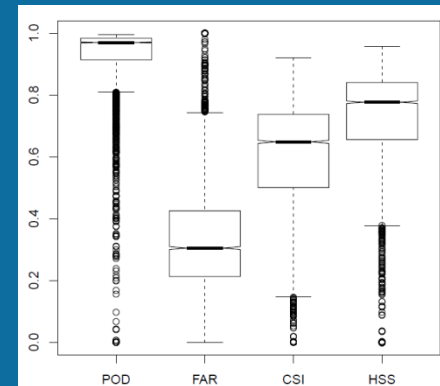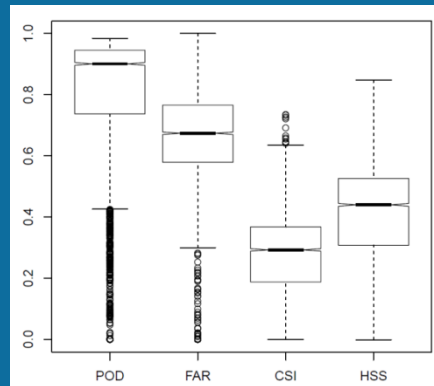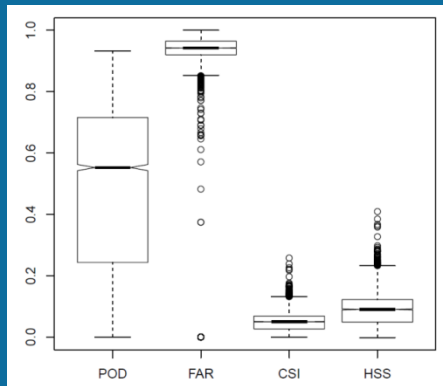
ANC Verification: Conclusions

- At a spatial scale of ~50 km and with no temporal relaxation, grid points with values ≥ 0.6 in ANC's 60-minute nowcasts of CL skillfully nowcast the general areas where both new storms may initiate and existing storms should be sustained.

- At a spatial scale of ~50 km and within 45 to 90 minutes from the nowcast issuance time, grid points with values ≥ 0.7 in ANC's 60-minute nowcasts of CL skillfully nowcast the general areas where new storms may initiate.

- ANC's 60-minute nowcasts of CL can best improve situational awareness when interpreted as guidance at a spatial scale of ~50 km and within a time frame anywhere between 45 and 90 minutes of the issuance times.

ANC: MDL Points of Contact

To express an interest in collaborative research and development with ANC, contact Dr. Stephan (Steve) Smith.

    Email: stephan.smith@noaa.gov

    Telephone: (301) 427-9495

For scientific questions about ANC, contact Dr. Mamoudou (Ama) Ba.

    Email: mamoudou.ba@noaa.gov

    Telephone: (301) 427-9477

For questions about the verification analysis, contact Dr. Lingyan Xin.

    Email: lingyan.xin@noaa.gov

    Telephone: (301) 427-9092

For technical questions about the ANC system, its configuration, etc., contact John Crockett.

    Email: john.crockett@noaa.gov

    Telephone: (301) 427-9469

ANC: Select Bibliography

- Mueller, C., T. Saxen, R. Roberts, J. Wilson, T. Betancourt, S. Dettling, N. Oien, and J. Yee, 2003: NCAR Auto-Nowcast System. *Wea. Forecasting*, 18, 545–561.

- Roberts, R. D., and S. Rutledge, 2003: Nowcasting storm initiation and growth using GOES-8 and WSR-88D data. *Wea. Forecasting*, 18, 562–584.

- Lakshmanan, V., J. Crockett, K. Sperow, M. Ba, and L. Xin, 2012: Tuning AutoNowCaster Automatically. *Wea. Forecasting*, 27, 1568–1579.

- Ba, M., L. Xin, J. Crockett, and S. Smith: Evaluation of NCAR's AutoNowCaster for Operational Application within the National Weather Service. Pending submission.